3.3. INERTIAL NAVIGATION SYSTEMS TEST TECHNIQUES

3.3.1. Initialization and Alignment

3.3.1.1. Purpose

The purpose of this test is to assess the INS initialization and alignment procedures for their utility for quickly reaching a full navigation status with a minimum of operator time and attention and the effect that these procedures have upon the set up sequence of other aircraft systems.

3.3.1.2. General

The INS initialization and alignment process is described in the navigation theory section. Initialization includes providing the INS with position and orientation inputs from which to reference the alignment. Alignment involves first leveling the platform and then orienting the true north axis to the geographic true north. Alignment is usually serially dependent upon initialization. The set up of other aircraft systems is sometimes partially dependent upon the presence of an INS alignment. As an example, geostable tactical displays require navigation input to operate. While alignment is taking place, the pilot will have many other tasks to perform, such as turning on other systems, starting the aircraft, attempting to obtain tactical SA, or putting on his flight gear and strapping into the aircraft seat. A quick and easy alignment process requiring a minimum of operator inputs and attention is essential.

Several factors can affect the initialization and alignment process. navigation control and display issues, addressed earlier can affect the time and effort required for the entry of the initialization parameters. Outside air temperature can affect alignment time. The colder the temperature of the INS, the longer the alignment will take. Motion of the aircraft can slow the alignment process. Actually moving the aircraft, whether by taxiing or towing, usually requires suspending the alignment with an additional penalty of time as the process is resumed. Alignment latitude can affect the alignment time. An alignment often will take longer at higher latitudes, with a significant delay above 70° latitude. Ship based alignments usually take 50% to 100% longer than shore based alignments. Most systems require four to ten minutes for the shore based initialization and alignment procedure. A wide variance of times can be obtained depending upon the factors listed above and so it is important to carefully record the conditions of the alignment. Since the alignment process takes a significant amount of time, a status indication should be provided to give the pilot an indication of the time left to a complete alignment and to provide feedback that the process is proceeding normally.

Ideally, the INS should be checked over the entire range of expected alignment conditions. Checking all conditions is rarely possible. A wide range of temperature conditions can require much travel, time, or expensive test chambers. Testing the alignment times over a variety of locations also requires expensive travel. This test procedure will be performed at the given test location and current atmospheric conditions providing a spot check of one possible condition. If a choice is available; however, it is always best to test at the expected operational conditions and secondarily at the extremes of the expected range of parameters. For this technique, ship based alignments will not be discussed. The ship based test technique is essentially the same except that automatic recording of the continuously changing position and orientation parameters is required.

The sample system includes an airborne alignment mode. An airborne alignment may be required if an alert launch has to be made before a ground alignment is complete, or after the loss of alignment with the aircraft airborne. An airborne alignment can take much more time than a ground alignment. A typical alignment may take twenty minutes or more. Typically, the alignment is begun by initializing the latitude and longitude to the correct position. This is often done by overflying a known position and initializing at the instant of the flyover. Most INSs require the aircraft to be flown straight and level as much as possible during the airborne alignment procedure. The airborne alignment test is nearly identical to the dynamic non-maneuvering position accuracy test and so a discussion of the procedure will be deferred until that section.

3.3.1.3. Instrumentation

A stop watch, thermometer (suitable for measuring outside air temperature) and data cards are required for this test. A voice recorder is optional.

3.3.1.4. Data Required

Record the time required to input the initialization parameters. Record qualitative comments concerning the ease and complexity of the data entry. Note if the initialization process interferes significantly with the start up and turn on procedures for the entire aircraft. Record the surveyed latitude and longitude of the aircraft, the actual heading of the aircraft during alignment (if available via an independent source such as a calibrated compass alignment rose), local magnetic variation and outside air temperature. If a compass rose is not available, record the surveyed alignment position, magnetic compass heading (with deviation applied) and magnetic variation. Record a complete description of aircraft motion during the alignment. For the interrupted alignment, record the elapsed time at interrupt, resumption of the alignment and a complete description of the aircraft movement. Include the new surveyed location and aircraft heading. At the completion of the alignment, record the INS displayed latitude and longitude, magnetic heading, true heading, magnetic variation and the total time for the alignment. Note qualitative comments concerning the utility of the INS alignment status indications including the alignment complete indication.

3.3.1.5. Procedure

Most airfields have a surveyed compass rose which is used for calibrating installed magnetic compasses. The center of the rose is accurately surveyed in latitude and longitude and magnetic headings are marked around the circumference of the rose. When possible, the alignment should be performed at the surveyed rose to provide accurate position and heading truth data. When a compass rose is not available, perform the alignment at any other surveyed location. Most hangars have surveyed parking slots on the ramp. In this case, an estimate of aircraft heading after alignment can be obtained using the magnetic compass, or some other portable magnetic heading source, with deviation applied. Local area magnetic variation should be obtained from published field charts, approach plates, en route charts, TPCs, etc.

Tow the test aircraft to the local compass rose and record the surveyed position, heading and magnetic variation. If a compass rose is not used, record the surveyed alignment location, the magnetic heading as displayed on the back up magnetic compass with deviation applied and the magnetic variation. Allow the INS to remain OFF for at least one hour before beginning the test to allow the components to cool to ambient temperature. Record the outside air temperature.

Using the procedure published for the INS, perform an INS initialization. Record the time required for initialization along with qualitative comments concerning the ease of the initialization procedures and the extent to which initialization distracts the pilot from turning on the entire aircraft. Following the initialization procedure, begin the alignment, starting the stopwatch as the alignment begins. As the alignment progresses, note the quality of the alignment progress status indicators and of the alignment complete indication. When the alignment is complete, note the total elapsed time, the indicated magnetic and true aircraft heading and the magnetic variation. Completely describe any aircraft motion during the alignment process. Repeat the initialization and alignment test before each test flight.

At least one interrupted alignment should be performed. Begin the alignment process at any surveyed point and then tow or taxi the aircraft to the surveyed compass rose to complete the alignment process. Record the parameters described above at both the first and second location. Note the elapsed time at interrupt and again when the alignment is resumed.

3.3.1.6. Data Analysis and Presentation

Relate the time required to perform the INS initialization, the complexity of the procedure and the overall operator intensity as a distraction to the pilot as he or she attempts to turn on other systems, straps into the aircraft, starts the engines and gains SA. Compare the initialized aircraft position at the start of the alignment (input by the operator) to the position at the time the alignment is complete. There should be no drift during the alignment process. Apply the actual aircraft heading on the compass rose and the local magnetic variation to equation (21) to obtain true heading. Where a compass rose is not used, apply the magnetic back up compass heading with deviation applied and local magnetic variation to equation (21) to obtain true heading. The accuracy of the truth data will be degraded. Compare the true heading, magnetic heading and magnetic variation provided by the INS at the time of the alignment to the actual values and relate the difference to the quality of the alignment, the effect that inaccuracies will have upon positional drift and the utility of INS headings for accurately navigating in a mission relatable ingress and attack.

Relate the quality of the status indicator, including the alignment complete indication, as a guide to how long the alignment has left to complete, as a source of confidence that the alignment is progressing normally and as an indicator that the aircraft has an operating navigation system with which to launch. Relate this to the time requirements and stress of an alert launch. Compare the alignment time to the time requirements of an alert launch and to the specification at the ambient temperature recorded during the test. If extreme variation in the alignment time and quality is noted during alignments where aircraft motion is a factor (for instance while maintenance personnel are climbing on the airplane) relate it to the requirement for pre-flight trouble shooting before aircraft launches. Compare the time for a suspended alignment less the actual time the alignment was suspended, to the time for an uninterrupted alignment. Relate any extreme variation to the requirement to occasionally move aircraft on a crowded ramp during a mass alert sortie.

3.3.1.7. Data Cards

Sample data card are provided as card 38.

CARD NUMBER ___

INITIALIZATION AND ALIGNMENT

ALIGNMENT LOCATION ___________

____

ALIGNMENT HEADING ___________

MAGNETIC VARIATION ___________

[ALLOW THE AIRCRAFT TO COLD SOAK FOR ONE HOUR. PERFORM A NORMAL INS INITIALIZATION.]

INITIALIZATION EASE/COMPLEXITY/EFFECTS UPON OTHER TURN ON AND START PROCEDURES:

INITIALIZATION TIME ___________

[START ALIGNMENT. START STOP WATCH.]

OUTSIDE AIR TEMPERATURE ___________

COMPLETELY DESCRIBE ANY AIRCRAFT MOVEMENT:

[IF THE AIRCRAFT IS TURNED OR TOWED, NOTE THE TIME OF THE SUSPENDED ALIGNMENT AND THE TIME OF THE RESTART.]

SUSPENDED ___________

RESTART ___________

DESCRIPTION OF AIRCRAFT MOVEMENT DURING SUSPENDED ALIGNMENT:

Card 38: Initialization and Alignment Data Cards

INITIALIZATION AND ALIGNMENT

FOR THE NEW AIRCRAFT LOCATION:

ALIGNMENT LOCATION __________

____

ALIGNMENT HEADING __________

MAGNETIC VARIATION __________

TIME TO COMPLETE THE ALIGNMENT __________

QUALITATIVE COMMENTS CONCERNING THE UTILITY OF THE ALIGNMENT STATUS AND THE ALIGNMENT COMPLETE INDICATORS:

WHEN ALIGNMENT COMPLETE:

DISPLAYED LOCATION __________

____

DISPLAYED MAGNETIC HEADING __________

DISPLAYED TRUE HEADING __________

DISPLAYED MAGNETIC VARIATION __________

WERE OTHER SYSTEMS/PROCEDURES WAITING ON THE ALIGNMENT? IF SO, DESCRIBE:

Card 38: Initialization and Alignment Data Cards (Continued)